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(54) Method for production of malt

(57) Cereal grain for malt is subjected to water absorption and germination and abscisic acid or a functional derivative thereof is applied to the cereal grain which is in the steeping process or the germination process. If desired, gibberellin or its functional derivative can be used in combination with abscisic acid or the functional derivatives thereof.

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SPECIFICATION
Method for production of malt

This invention relates to a method for production of malt.

Malt, which is useful as a starting material for brewing, is being produced by a method which comprises subjecting cereal grain for malt to steeping and germination. In such a conventional process, the quality of the malt is lowered when the yield of the malt is increased. Therefore, a method which comprises applying gibberellin to the cereal grain in the malting process step to shorten the period for germination and thereby to seek an increase in malt yield and decrease in cost and, moreover, to prevent deterioration of quality has been reduced to practice. Gibberellin is also being utilized to produce malt of high quality from barley of low quality.

The use of gibberellin, however, is not desirable because the wort prepared from the malt produced by the use of gibberellin has defects such as the deepened color of wort.

In order to solve such problems with respect to the use of gibberellin, $KBrO_3$ has been practically used in combination with gibberellin. However, $KBrO_3$ is said to have mutagenicity, and thus the use thereof is not desired from the viewpoint of food hygiene. The use of various chemicals other than $KBrO_3$ has also been proposed, but in all these cases the use of these chemicals has low practical value because of food hygiene problems and the like.

It is an object of the present invention to solve the above described problems. This object has been accomplished by the use of abscisic acid or a functional derivative thereof instead of $KBrO_3$ or other chemicals.

Thus, the method for production of malt in accordance with the present invention comprises subjecting cereal grain for malt to steeping, viz. water-absorption, and germination and is characterized in that an abscisic compound which is abscisic acid or a functional derivative thereof is applied to the cereal grain which is in the steeping process or the germination process.

A feature of the present invention resides in the use of abscisic acid or a functional derivative thereof, which can be used if so desired in combination with other chemicals as long as this feature is not impaired. One group of such chemicals is gibberellin or a functional derivative thereof.

Thus, the method for production of malt in accordance with the present invention in another aspect thereof comprises subjecting cereal grain for malt to steeping and germination, and is characterized in that both the abscisic compound and a gibberellic compound which is gibberellin and/or a functional derivative thereof are applied to the cereal grain which is in a process stage of steeping or germination.

The term "cereal grain for malt" herein refers to cereal grain for use in brewing. Among the grains that so named are barley, wheat, rye, oats, and various other cereal grains such as millet and sorghăm. Barley is the most typical.

Abscisic acid to be used for malting in accordance with the present invention is not a synthetic compound but a plant hormone which is generally contained in cereals, vegetables, fruits and the like. Thus, there is no food hygiene problem or risk in operations as in the case of $KBrO_3$ and other chemicals. Furthermore, abscisic acid or the like can exhibit a marked effect at a very low concentration in comparison with $KBrO_3$ and the like. For example, $KBrO_3$ has been used in a quantity of about 100 ppm on the basis of barley weight, but abscisic acid or the like is effective even in a quantity of 0.1 to 1 ppm, as described below in detail.

By the addition of abscisic acid to barley in the course of the malting process, the growth of rootlets is inhibited to increase the yield of malt. At the same time, excessive decomposition of proteins is controlled, and the amount of free amino acids is decreased in the wort prepared from the resulting malt because formation of protease is inhibited. Further, the degree of coloring wort due to formation of melanoidine is decreased because of decrease in the content of glucose or maltotriose in the wort which is caused by inhibition of α-amylase formation. Moreover, fermentability is improved because of increase in the maltose content in the wort, and the extract content is also increased by the concomitant use of gibberellin.

It is known that the biosynthesis of α-amylase in the aleurone layer of barley is promoted by gibberellin (especially GA_3) but abscisic acid (hereinafter sometimes referred to as ABA) hinders the biosynthesis [Plant Physiol. *42,* 1008 (1967) and Nature, *205,* 1270 (1965)]. It has also been made clear that the mechanism of inhibition of the α-amylase-biosynthesis by ABA is not due to the hindrance of m-RNA induction of GA_3 but due to the hindrance of translation of m-RNA into protein [Cell, *20,* 479 (1980)]. In these reports, the effects of ABA on the induction of m-RNA and formation of α-amylase were researched by adding GA_3 and ABA in combination to the endosperm or isolated aleurone layer of barley.

These researches, however, do not teach or suggest the manifestation of special effects achieved according to the present invention, that is, by addition of both GA_3 and ABA to barley in a malting stage, (i) the yield of malt, yield of extract and diastatic power can be increased, and, moreover, (ii) the fermentability of the resulting wort is improved, and also the decomposition of proteins and the color of wort can be controlled at will, and other effects. In this connection, general reports which teach that the balance of certain four plant hormones is required in the formation of α-amylase are known [European

Brewery Convention Proceedings of the 14th Congress (Salzburg), p. 75, (1973), (and that of the 16th Congress (Amsterdam), p. 63 (1977)]. The special effects mentioned above, however, also could not be anticipated from the above named reports.

The method of producing malt will now be described in specific detail.

1. *Malting process*

The present invention can be applied to conventional malting processes. With reference to the present invention, the malting process is defined to comprise causing grain for malt to absorb water and germinate.

The methods for production of malt which comprise causing the grain to absorb water and germinate are well known in the art, and thus no description thereof in detail will be needed herein. If necessary, one can refer to, for example, "Barley and Malt Biology, Biochemistry, Technology, Ed. A. H. COOK, Academic Press, 1962, p.p. 271—302." for the details of the malting method, the literature being incorporated herein by reference. In addition to the essential stages of steeping and germination which are closely related to the present invention, additional stages before, between or after these two stages such as drying, removal of malt rootlets and other treatment may be conducted.

The present invention can also be applied to the processes for production of germinated products of other grain (such as rice, beans and Indian corn), other seeds, and starchy tubers such as various potatoes.

2. *Abscisic compounds*

Abscisic compounds which are abscisic acid and its functional derivatives are known plant hormones, the details of which are given in, for example, ANNUAL REVIEW OF PLANT PHYSIOLOGY Vol. 25, p 259—307 (1974) published by ANNUAL REVIEWS INC. Palo Alto, California, U. S. A.

By the functional derivatives of abscisic acid are meant the derivatives with respect to the carboxylic acid moiety of abscisic acid, especially water-soluble salts and esters. Among the salts are included the salts thereof which are allowable in view of food hygiene such as the alkali metal salts, alkaline earth metal salts and ammonium salts thereof. Included among the esters are the esters with lower alcohols and especially monohydric lower alkanols having 1 to about 4 carbon atoms as well as the esters with sugars, lower alkyl (C_1—C_4) esters being preferable.

Other functional derivatives of abscisic acid to be used in the present invention are the derivatives with respect to the moieties other than the carboxylic acid moiety. Such derivatives include, for example, xanthoxic acid, hydroxyabscisic acid, phaseic acid, and dihydrophaseic acid. Moreover, xanthoxins are other functional derivatives of abscisic acid which contain both an aldehyde moiety instead of the carboxylic acid moiety and a 6-membered ring substituent moiety. The acid and esters thereof can also be used in the present invention.

The amount of abscisic acid or a derivative thereof to be used in the present invention is given below.

3. *Gibberellic compounds*

Gibberellic compounds which are gibberellin and its functional derivatives, which can be used in combination with the abscisic compounds in accordance with the present invention, are also known plant hormones.

As the gibberellin are known a compound called GA_3 as well as compounds called GA_1, GA_4, GA_7 and GA_9. It is also known that the gibberellin used actually in malt-production industries consists essentially of a mixture of these gibberellin compounds [J. Inst. Brew. *80*, 13—30 (1974)]. The term "gibberellin" used herein encompasses both any single compound (e.g. GA_1 as given in the specification of Japanese Patent Application No. 67661/81) and any mixture thereof. The term "the functional derivatives" of gibberellin encompasses the salts and esters thereof, as described in the corresponding paragraph for abscisic acid.

4. *Treatment of grain for malt*

The abscisic compound is applied to grain for malt either (i) in the steeping process of the grain, viz. when the grain is in the water-absorption stage, that is, in the period from the start of the step of contacting the grain with water, ordinarily by steeping in water or sprinkling with water, to the point of time just before the grain begins to germinate with absorption of a required amount of water, which may be about 37 to about 46% of water content in the grain, or (ii) in the germination process, viz. when the grain is in the germination stage, or in the stage of from the start to the termination of germination. In other words, the abscisic compound is applied to grain from the stage of starting the water-absorption by contacting the grain with water to the stage of terminating the germination.

More specifically, the abscisic compound can be applied to the grain for malt, by dissolving the abscisic compound in the water in which the grain is to be steeped, or by sprinkling an aqueous solution of the abscisic compound onto the grain and especially the grain which has absorbed water by steeping.

The quantity of the abscisic compound to be used can be an optional value as long as it is reasonable. More specifically, the quantity to be used is approximately in the range of 0.001 to

100 ppm, preferably 0.01 to 10 ppm and ordinarily 0.1 to 1 ppm on the basis of the weight of cereal grain (before steeping), in the case of sprinkling the aqueous solution onto cereal grain which has absorbed water by immersion. When the abscisic compound is applied by other methods, the amount thereof to be taken up in the cereal grain can be selected to fall within the above-defined range.

The quantity of gibberellic compound, when it is used in combination with the abscisic compound, can be an optional value as long as it is reasonable. More specifically, in the case of sprinkling an aqueous solution of these compounds onto cereal grain which has absorbed water through immersion, the quantity is approximately in the range of 0.001 to 10 ppm and preferably 0.01 to 1 ppm on the basis of the weight of the cereal grain (before water-absorption). When it is applied by other methods, the quantity thereof to be taken up on the cereal grain can be selected to fall within the above described range.

After application of the abscisic compound to the grain for malt, it is necessary to keep the contact of the abscisic compound with the grain until the effect of the physiological activity of the abscisic compound on the grain is exhibited as expected. Also in this respect, it is preferable to apply the abscisic compound to the grain before the stage of germination. When the abscisic compound is applied near the termination of the germination stage, it is necessary to allow the treated grain to stand under the conditions for about 12 hours after the termination of the germination stage.

5. *Examples of Experiments*

EXAMPLE 1

One (1) kg of malted barley (New Golden variety) cultinated in Yamanashi Prefecture, Japan, was steeped in water at 15°C for 6 hours and then drained for 6 hours. This operation was repeated several times until the water content of the barley reached 43%, and then the barley was drained for 2 hours. An aqueous solution of abscisic acid having a concentration of 1×10^{-3}% or 1×10^{-2}% (g/v) was sprinkled onto the treated barley so that the quantity of abscisic acid sprinkled corresponded to 0.1 or 1 mg. The barley thus treated was subjected to germination for 6 full days in an experimental malting apparatus and then was dried in a kiln to produce malt. The analytical data of the resulting malt are shown in Table 1. In the suitable range of abscisic acid concentrations, the yield of malt was increased in comparison with the control, the decomposition of proteins was inhibited, and the color of wort was lowered. Thus, by the application of abscisic acid to the process for production of barley malt in the case where barley having a germination force strong enough to lower the yield of malt or barley having protein-decomposition power strong enough to deepen the color of wort is used, the yield of malt can be increased, and the decomposition of proteins and the color of wort can be controlled at will.

TABLE 1

	Control	Abscisic acid added	
		0.1 ppm*	1 ppm*
Yield of malt (d.m., %)	90.7	91.0	91.6
Content of extract (d.m., %)	79.4	78.8	77.8
Formol nitrogen (mg /100 ml wort)	29.6	28.0	22.2
Kolbach Index (%)	47.6	44.2	37.1
Color of wort (EBC unit)	4.7	4.4	3.4
Diastatic power (°W.K.)	196	201	170
Apparent attenuation limit of wort (%)	82.2	82.5	81.0

Note: * mg /kg barley (as is).

EXAMPLE 2

As in Example 1, a mixture of abscisic acid and GA_3 (0.1 mg per kg of barley) was sprinkled onto barley after steeping in water to prepare malt. Analytical data of the resulting malt are shown in Table 2. In the suitable range of abscisic acid concentrations, the yield of malt and the content of extract were increased, and the decomposition of proteins was satisfactorily controlled. Malt of very good quality, wherein the conventional marked increase in the color of wort caused by addition of GA_3 was inhibited, was obtained. The malt had high diastatic power and the apparent attenuation limit of wort was normal.

TABLE 2

Quantity of absicisic acid added (ppm*)	0	0	0.1	1
Quantity of GA_3 added (ppm*)	0	0.1	0.1	0.1
Yield of malt (d.m., %)	90.7	90.8	91.2	91.2
Extract content (d.m., %)	79.4	80.2	80.0	80.0
Formol nitrogen (mg / 100 ml wort)	29.6	33.5	31.8	25.4
Kolbach Index (%)	47.6	51.5	49.7	40.7
Color of wort (EBC unit)	4.7	6.9	5.3	4.1
Diastatic power (°W.K.)	196	206	211	213
Apparent attenuation limit of wort (%)	82.2	81.6	82.4	83.1

Note : * mg /kg barley (as is).

EXAMPLE 3

As in Example 1, 0.1 ppm of GA_3 was sprinkled onto barley after steeping in water (10 ml of an aqueous solution of $1 \times 10^{-3}\%$ (g/v) per kg of barley), and the barley thus treated was subjected to germination for 24 hours in an experimental malting apparatus. Then, abscisic acid was sprinkled as described in Example 1 and the germination operation was continued to produce malt. Analytical data of the resulting malt are shown in Table 3. In the suitable concentration range of abscisic acid, malt of a very good quality was obtained as in Example 2, although the effect of GA_3 was observed to be stronger than that in the case of Example 2.

TABLE 3

Quantity of abscisic acid added (ppm*)	0	0	0.1	1	10
Quantity of GA_3 added (ppm*)	0	0.1	0.1	0.1	0.1
Yield of malt (d.m., %)	90.6	90.6	90.8	90.7	90.7
Extract content (d.m., %)	79.2	80.3	80.2	79.5	78.6
Formol nitrogen (mg /100 ml wort)	28.5	33.6	32.1	28.8	23.4
Kolbach Index (%)	46.1	52.9	51.2	47.3	40.6
Color of wort (EBC unit)	5.3	9.4	8.1	5.9	5.0
Diastatic power (°W.K.)	177	169	181	188	160
Apparent attenuation limit of wort (%)	81.5	81.2	81.6	81.9	81.0

Note: * mg /kg barley (as is).

EXAMPLE 4

Methyl abscisate adn GA_3 were sprinkled as in Example 2 onto malting barley (New Golden variety), which had been sleeped in water to have a water content of 42% and then drained for 2 hours in the same manner as in Example 1, to produce malt. Analytical data of the resulting malt are shown in Table 4. The effect of methyl abscisate was clearly exhibited. As in the case of abscisic acid (Example 2), by the addition of a suitable quantity of methyl abscisate, the quality of malt could be controlled at will.

TABLE 4

Quantity of methyl abscisate added (ppm*)	0	0	0.1	1
Quantity of GA_3 added (ppm*)	0	0.1	0.1	0.1
Yield of malt (d.m., %)	91.1	91.2	91.2	91.7
Extract content (d.m., %)	79.1	79.9	79.8	79.0
Formol nitrogen (mg /100 ml wort)	24.1	29.6	26.5	22.0
Kolbach Index (%)	44.8	49.0	47.0	41.5
Color of wort (EBC unit)	3.1	4.9	3.9	3.3
Diastatic power (°W.K.)	229	227	232	211
Apparent attenuation limit of wort (%)	83.0	83.3	83.4	81.5

Note: * mg /kg barley (as is).

EXAMPLE 5

Abscisic acid and GA_3 were sprinkled as in Example 2 onto malting barley (New Golden variety) which had been steeped in water to have a water content of 41% and then drained for 2 hours in the same manner as in Example 1. The barley thus treated was subjected to germination in an experimental malting apparatus, sampled on the 3rd, 4th and 5th full days, and dried in a kiln to produce malt. Analytical data of the resulting malt are shown in Table 5. When GA_3 alone was used, the Kolbach Index and color of wort were abnormally increased, although the period for germination could be shortened by 1 or 2 days. On the other hand, when a suitable concentration range of abscisic acid was used in combination with GA_3, malt of good quality, in which the increase in the Kolbach Index and the wort color was suitably controlled, could be obtained in a higher yield in a shorter germination period in comparison with control samples.

TABLE 5

Quantity of abscisic acid added (ppm*)	0	0			0.1			1.0		
Quantity of GA_3 added (ppm*)	0	0.1			0.1			0.1		
Days for germination	5	3	4	5	3	4	5	3	4	5
Yield of malt (d.m., %)	87.2	89.3	88.3	87.2	90.0	88.7	87.4	90.5	89.4	88.4
Extract content (d.m., %)	79.2	78.7	79.5	79.9	78.6	79.3	79.6	77.9	78.5	79.0
Formol nitrogen (mg/100 ml wort)	25.2	26.2	28.4	29.0	23.4	26.1	25.3	17.4	19.6	22.8
Kolbach Index (%)	43.2	44.3	48.2	48.8	40.9	44.8	45.4	35.3	36.0	37.7
Color of wort (EBC unit)	3.8	4.2	4.7	5.2	3.1	3.8	4.1	2.9	3.5	3.7
Diastatic power (°W.K.)	216	200	225	217	190	210	223	163	183	181

Note: * mg/kg barley (as is)

CLAIMS

1. In a method for production of malt which comprises subjecting cereal grain for malt to steeping and germination, an improvement wherein an abscisic compound which is abscisic acid and/or functional derivative thereof is applied to the cereal grain which is in the steeping process or the germination process.

2. The method for production of malt according to claim 1, in which the abscisic compound is abscisic acid.

3. The method for production of malt according to claim 1, in which the abscisic compound is a water soluble salt or abscisic acid.

4. The method for production of malt according to claim 1, in which the abscisic compound is a lower alkylester of abscisic acid.

5. The method for production of malt according to claim 1, in which the quantity of the abscisic compound is in the range of 0.001 to 100 ppm on the basis of the weight of the cereal grain for malt before steeping.

6. The method for production of malt according to claim 1, in which a gibberellic compound which is gibberellin and/or functional derivative thereof is further applied to the cereal grain for malt which is in the steeping process or the germination process.

7. The method for production of malt according to claim 6, in which the gibberellic compound is gibberellin.

8. The method for production of malt according to claim 6, in which the gibberellin is GA_3.

9. The method for production of malt according to claim 6, in which the quantity of the gibberellic compound is in the range of 0.001 to 10 ppm on the basis of the weight of the cereal grain for malt before steeping.

10. A method for production of malt substantially as herein described.

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